FAA Aging Electrical Systems Research Program Update

Prepared for:
Aging Transport Systems Rulemaking Advisory Committee
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Aging Electrical Systems Research Program AAR-433

Wire Degradation Research

Core Technical Team

- Raytheon Technical Services Company, Indianapolis
- Brookhaven National Laboratory
- Lectromechanical Design Co. (Lectromec)
- Sandia National Laboratory

Wire Degradation Research

Additional Industry Stakeholders

- OEMs
- Wire Processors and Material Manufacturers
- Airline Operators and Maintenance Representatives
- Military Representatives
- Other Industry Experts

Wire Degradation Research

Overall Goal

- Model aging characteristics of aircraft wire
  - Establish predictive techniques.
  - Determine degradation relative to original performance specification.

Wire Degradation Research

Specific Goals

- Understand degradation mechanisms
- Model behavior of these mechanisms
- Establish relationships between performance degradation and potential failure modes
- Understand critical performance degradation thresholds
- Determine how thresholds can be used to eliminate or mitigate potential wiring hazards
- Identify major model perturbations

Wire Degradation Research

- Phase 1: Define Test Plan and QA Documentation

  Aug 2001 - Apr 2002

- Phase 2: Testing of Aircraft Wire

  May 2002 - Jul 2003

- Phase 3: Analysis and Reporting

  May 2002 - Dec 2003

Wire Degradation Research

Phase I Tasks

- Pull in industry experts and stakeholders
- Identify types of polymer degradation
- Identify significant degradation variables and levels
- Define areas of the aircraft - establish environment
- Identify appropriate test methods
- Determine experimental design
- Define Perturbations
- Establish QC system for program
- Acquire test materials/samples

Wire Degradation Research

TASK	DATE	STATUS
• Contract Award	Aug 01	Complete
• Award Subcontracts for core technical team	Sept 01	Complete
• Technical Kickoff Meeting	Nov 01	Complete
• Identify Major Wire Aging Variables	Dec 01	Complete
• Identify Major Perturbations to Aging Process	Dec 01	Complete
• Determine Testing Levels and Failure Criteria	Jan 02	In process
• Draft Test Plan	Jan 02	In process
• Procure Test Samples	Mar 02	
• Define Phase 2 Tasks and Schedule	Mar 02	
• Quality Assurance Plan	Apr 02	
• Finalize Experimental Design and Test Plan	Apr 02	
• Begin Phase II – Testing	May 02	

Arc Fault Circuit Breaker Update

Arc Fault Circuit Breaker

- Eaton Aerospace development contract complete.

- All objectives successfully completed.

Arc Fault Circuit Breaker

- Hendry Telephone AFCB development on schedule
- Deliver prototypes for environmental/safety testing – Feb 2002
- Environmental/safety testing: Feb-Apr 2002
- Begin Navy flight testing: May 2002
- Begin FAA flight testing: July 2002

Arc Fault Circuit Breaker

- FAA has accepted and is processing an STC for 737 AFCB installation
    - Single circuit
    - Non-flight critical
    - Evaluation/data gathering purposes
- Installation targeted for April/May 2002

Arc Fault Circuit Breaker

Phase II AFCB Development

- Joint FAA, NAVAIRSYSCOM, ONR, AF program
- Broad Area Announcement
  - 28VDC, 1-25A
  - Three-phase, 5-25A
  - MS3320 package
  - Communication interface
  - Remote control
  - Integration of 115V/400Hz AFCB and 28VDC into single breaker
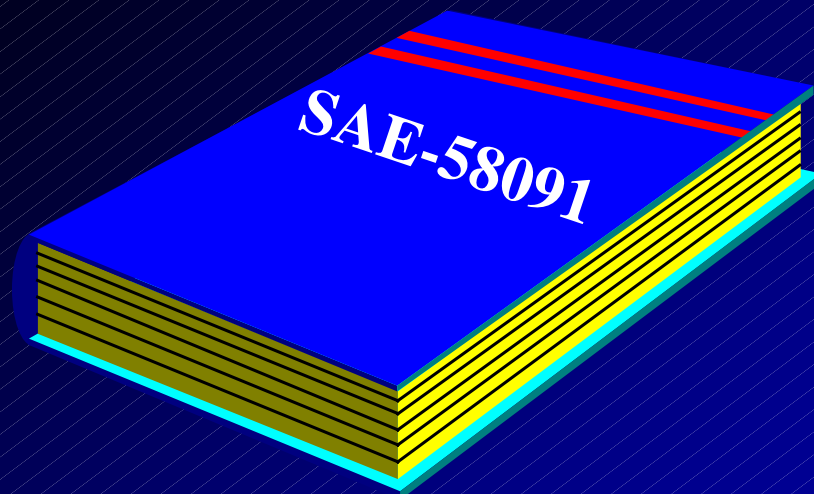
Arc Fault Circuit Breaker

Phase II AFCB Development

- BAA will be issued by ONR

- White Papers

- Full Proposals

- Multiple awards

- Three-year program

SAE-8B1 AFCB Specification

- Slow but steady progress
- Core member meeting – March

- New DOD slash sheets a possible stop-gap solution

SAE-58091

Aging Circuit Breaker Testing

Aging Circuit Breaker Testing

Objective

Determine extent of circuit breaker degradation in aged aircraft relative to the original performance specifications.

Aging Circuit Breaker Testing

Twelve panels from two aircraft

- Process 1 testing complete
  - 200% & 500% overload
  - 60 Breakers
  - 4 Test Failures
    - One breaker would not close
    - Two breakers tripped prematurely on 200% test
    - One breaker tripped immediately on 200% test

Aging Circuit Breaker Testing

Loose Terminal Post Screw
Numerous Occurrences
Also:
Inconsistent application of screws
and washers

Blackened Sleeve
High Temperature
Also:
Multiple circuits terminated to
same breaker

Aging Circuit Breaker Testing

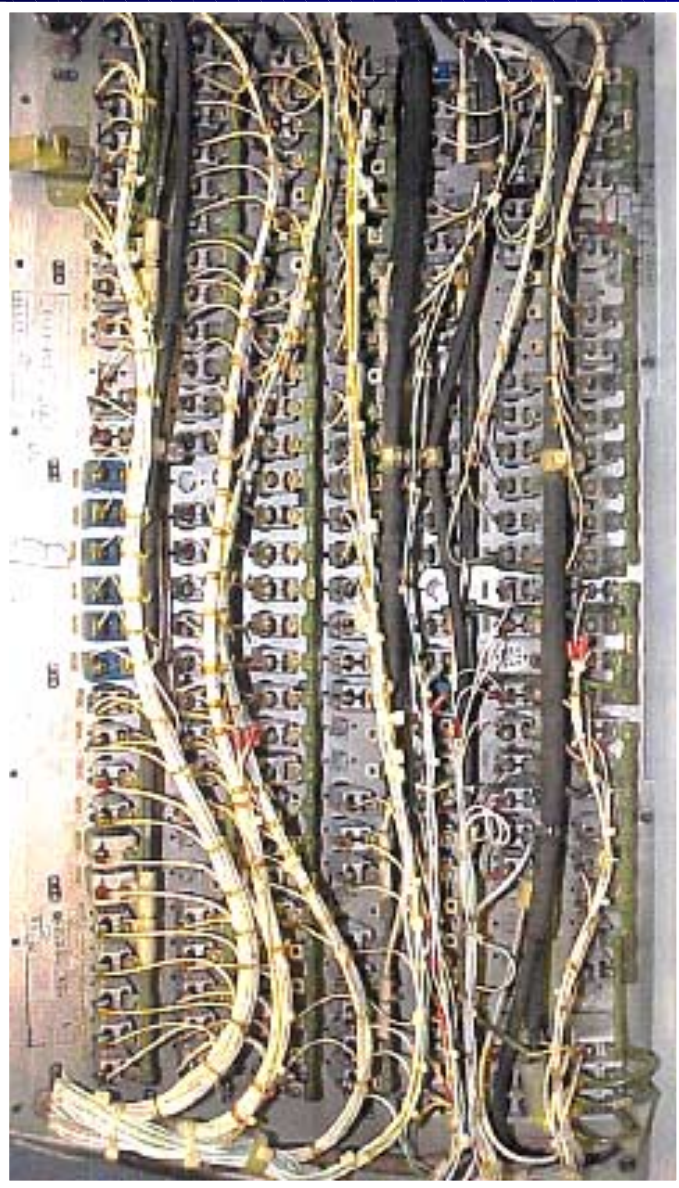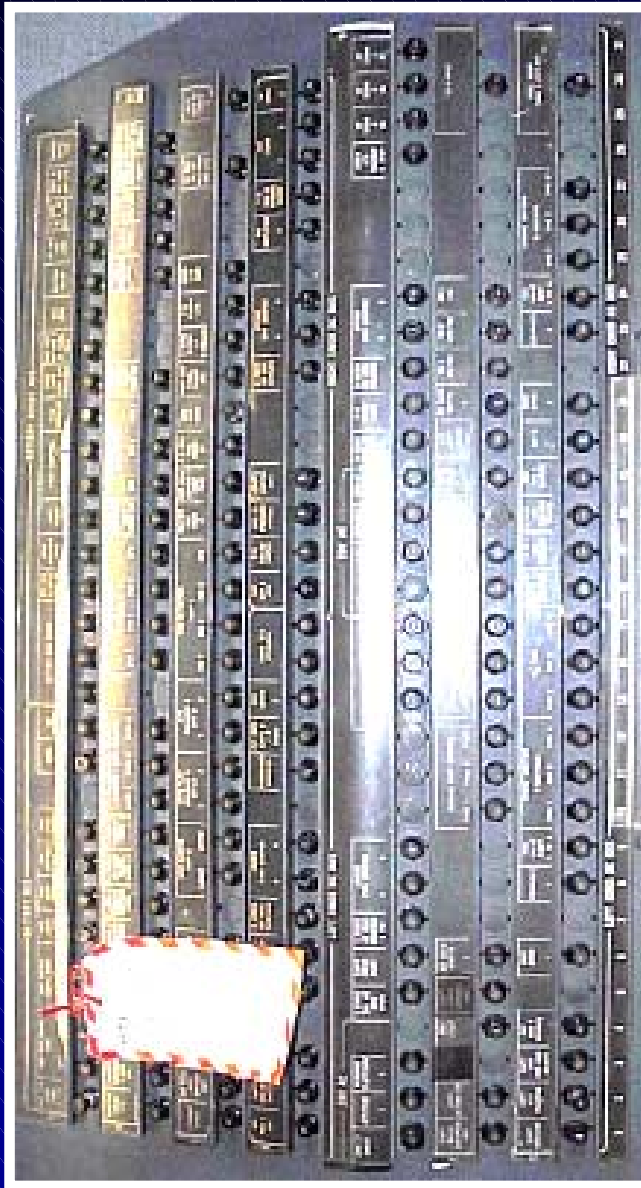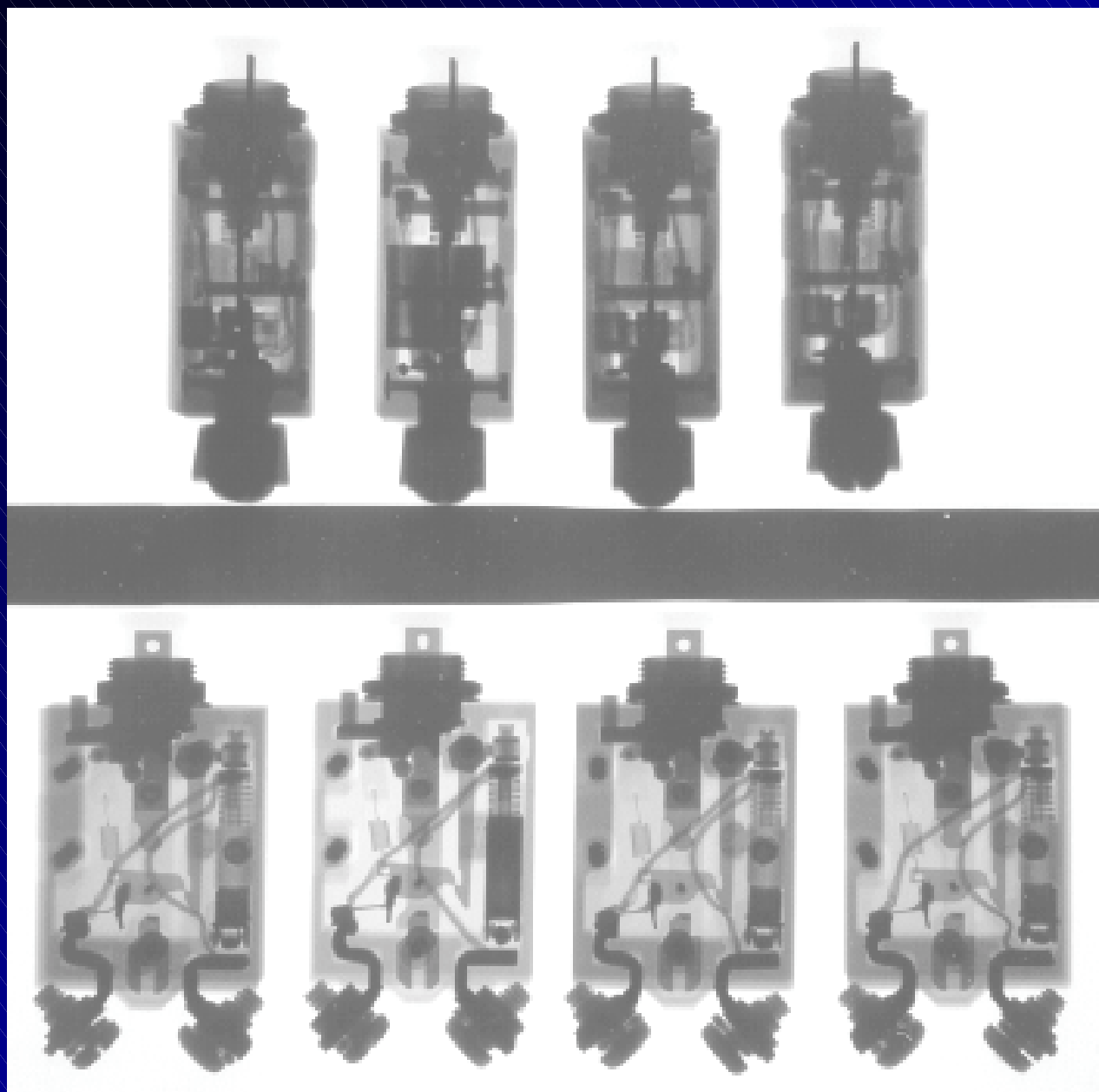Evidence of arcing or high temperature connection

Aging Circuit Breaker Testing

Process 2 testing completed

- – Full MIL-C-5809 test regimen
- – 240 Breakers
- – X-Ray
- – Failure analysis
- – Final report – March 2002

Aging Circuit Breaker Testing

Process 2 Test Results

- Dielectric withstand – all pass

- Insulation resistance – all pass

- Pull-out and reset button forces – all pass

Aging Circuit Breaker Testing

Process 2 Test Results

- Voltage drop
  - Not specified for all breaker types
  - Some exceeded specification
  - Voltage drop reductions noted after repeated cycling of breaker
  - Further data analysis underway

Aging Circuit Breaker Testing

Process 2 Test Results

- Minimum Limit of Ultimate Trip
  - Breaker must stay closed for one hour at a specified current (such as 115% of rating)
  - Some breakers opened prematurely
  - All pass at 90% (such as 90% of 115%)

Aging Circuit Breaker Testing

Process 2 Test Results

- Maximum Limit of Ultimate Trip
  - Breaker must open within one hour at a specified current (such as 138% of rating)
  - Some breakers did not open
  - All but one opened at 110% (as in 110% of 138%)
  - Further data analysis is underway

Aging Circuit Breaker Testing

Process 2 Test Results

- Overload Calibration
  - 200%, 400%, 500%, 600%
  - Must trip within time limit in specification
  - Some failures – tripped beyond the maximum specified calibration value or before minimum (if specified)
  - All breakers opened
  - Further data analysis underway

Aging Circuit Breaker Testing

General Recommendations

- Review multiple terminations
  - ARP-1199 and ARP-4404 cautions against practice
  - Multiple circuits lost in event of trip
  - Greater difficulty in identifying source of trip

Aging Circuit Breaker Testing

General Recommendations

- Improved Inspection/Maintenance
  - Loose connections
  - Incorrect hardware
  - Signs of arcing and high temperature
  - Cleanliness
- Periodic cycling of circuit breakers

Aging Circuit Breaker Testing

General Recommendations

- Replacement of breakers that cannot be opened without difficulty

- Adopt standard date codes

- Do not return used breakers to supply

Aging Circuit Breaker Testing

- Additional analysis of data to assess performance of breakers used as switches

- All analysis complete by 30 March

- Limited follow-on testing as necessary

Advanced Risk Assessment Methods for Aircraft Electrical Systems

Advanced Risk Assessment Methods for Aircraft Electrical Systems

Develop advanced EIS risk assessment tools.

- Accidents and incidents that have occurred in the past indicate the current tools used in the development and assessment of EIS during the design process and during EIS modifications may not identify all potential failure modes.

Advanced Risk Assessment Methods for Aircraft Electrical Systems

- Contract negotiation in progress

- Objective is to develop tools to enhance the risk assessment process and facilitate compliance with Part 25.1309(b)

Wire Test & Inspection Technology

Wire Test & Inspection Technology

CM Technologies – EDT Validation

- DC-9 test bed
- Circuits evaluated
  - Fuel pump motor
  - Generator wiring
  - APU circuits
  - PA system
- Circuit selection based on safety and maintenance history

Wire Test & Inspection Technology

CM Technologies – EDT Validation

- Analysis of results underway

- Preliminary analysis has identified impedance anomalies at an intermediate connection in the fuel pump circuits

- Complete validation report 30 March

Wire Test & Inspection Technology

New Contracts

- Intelligent Automation, Inc.

  – Wiring Integrity Verification Using Pseudo-Random Binary Sequence

  – Form of reflectometry

  – Low power - Can be used on operating circuits

Wire Test & Inspection Technology

New Contracts

- Williams-Pyro, Inc.
  - Active Automatic Diagnostic System for Aircraft
  - Feasibility of Frequency Domain Reflectometry
  - Neural Network algorithms for fault categorization
  - Smart Inserts
  - Interrogator unit

Wire Test & Inspection Technology

- Killdeer Mountain Manufacturing – Wire Chafing Detection Technology

- Prototype testing this week at the Air Force Research Lab/WPAFB

Other Research

- Wire Performance & Test Specifications
  - Research Plan – complete
  - Procurement process underway
- Evaluation of Mixed Wire Types
  - Draft Research Plan – complete
  - FAA review in-process. Complete by 01/25/02.

Other Research

- Evaluation of Maintenance Effects
  - Draft Research Plan – complete
  - FAA review in-process. Complete by 01/25/02.
- Evaluation of Wire Separation/Segregation
  - Research Plan under development. Complete by 01/25/02.

Questions??